Two Diamonds in the Rough

NETL's COMBUSTION TECHNOLOGIES PROGRAM

And

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Why Combustion?

Combustion has been --and remains-- the lowest cost, most direct way to produce electricity

Why Combustion?

- Over three quarters of all the electricity in the US is produced by Combustion (Coal, Gas, Oil, Syngas, and Bio-mass) based power plants.
- Over half of the electricity is produced by solid fuel (coal-fired) Combustion power plants.

- Improvement, Expansion, Repowering of current Combustion power plant fleet and Advanced Combustors based on proven concepts are opportunities for today's and tomorrow's power generators.

What Can We Do To Promote Future Combustion Technologies

COMBUSTION TECHNOLOGIES UNIVERSITY ALLIANCE

Collaboration and Communication
Between
University, Industry, and Government Researchers

Combustion Technologies University Alliance Is An *Applied Research Program*

Basic Research (Science) **- Any research that is conducted for the purpose of investigation into the nature of something in order to obtain knowledge about the subject, as distinguished from *applied research*, which has more practical goals.**

However, knowledge gained through basic research is put to practical uses through applied research.

U.S. Department of Energy
Office of Fossil Energy

The Combustion Technologies Program
under the

DOE's Office of Fossil Energy is a

Coal Based Program

Electric Power Using Coal

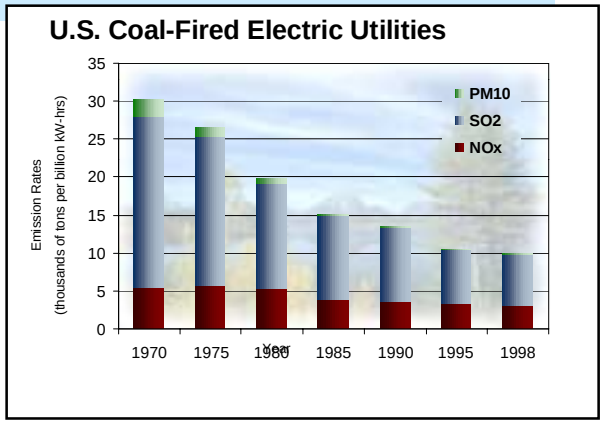
Coal…Satisfying Our Country's Need for Energy Now and in the Future

Adaptable

Coal is Cleaner than Ever
- **NO_x emissions: Reduced by almost one-half**
- **SO_2 emissions: Reduced by more than two thirds**
- **Particulate emissions: One-tenth of what they were 30 years ago**

The By-Products of Coal Combustion Can be Recycled
- **This makes coal even more environmentally friendly**

Current Research Will Result in Clean Coal
- **New Technologies will reduce emissions of fine particulates, carbon dioxide, air toxics and mercury**



Affordable

Coal is the least expensive fossil fuel available to the United States

For the decade 1988 - 1997, coal prices declined by 37% and from year 2002 to 2020 are projected to decline by 1.1% per year

Our country benefits from one of the lowest electricity rates on earth due to the low cost of coal

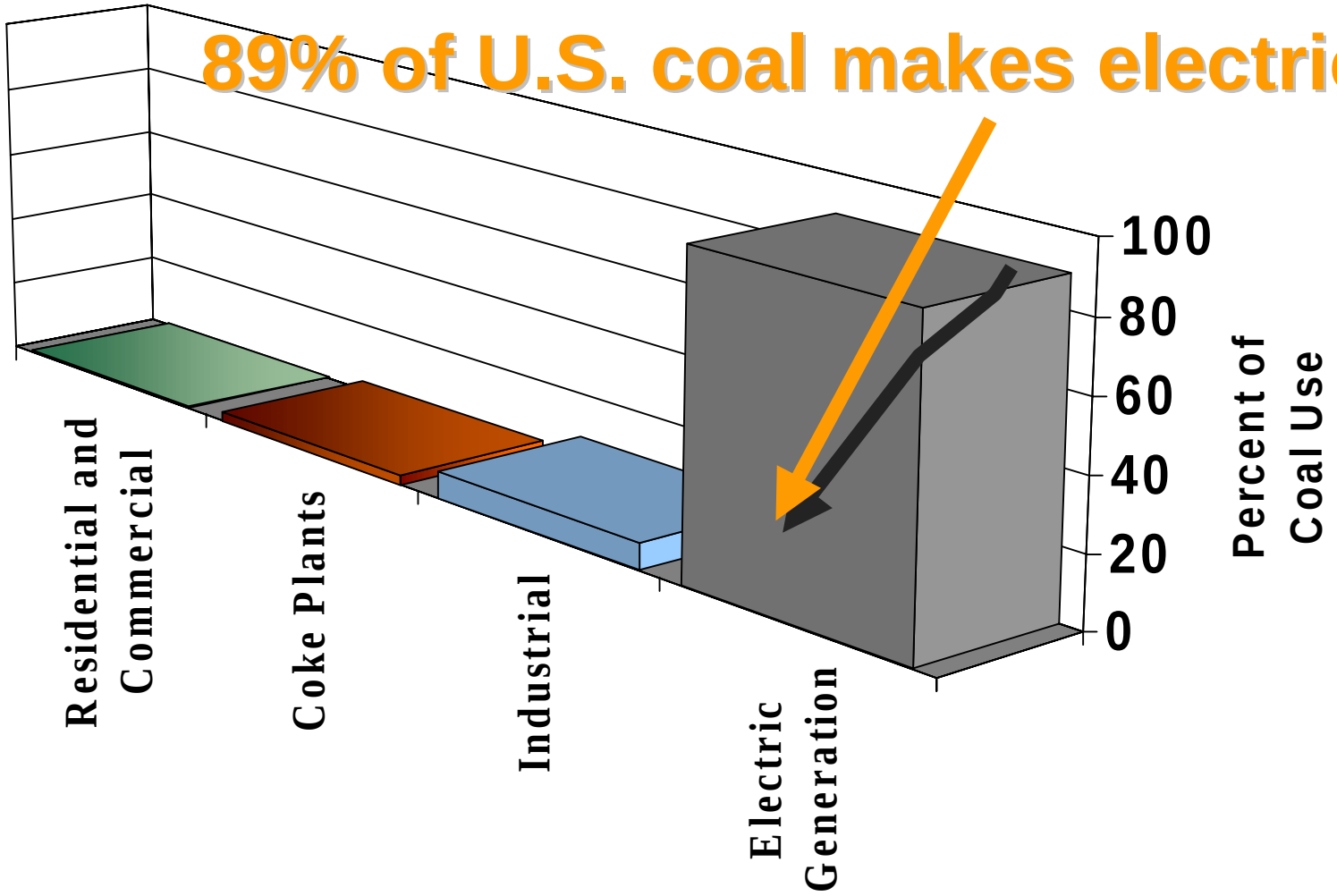
Abundant

One quarter of all the world's known coal supplies are found within the United States

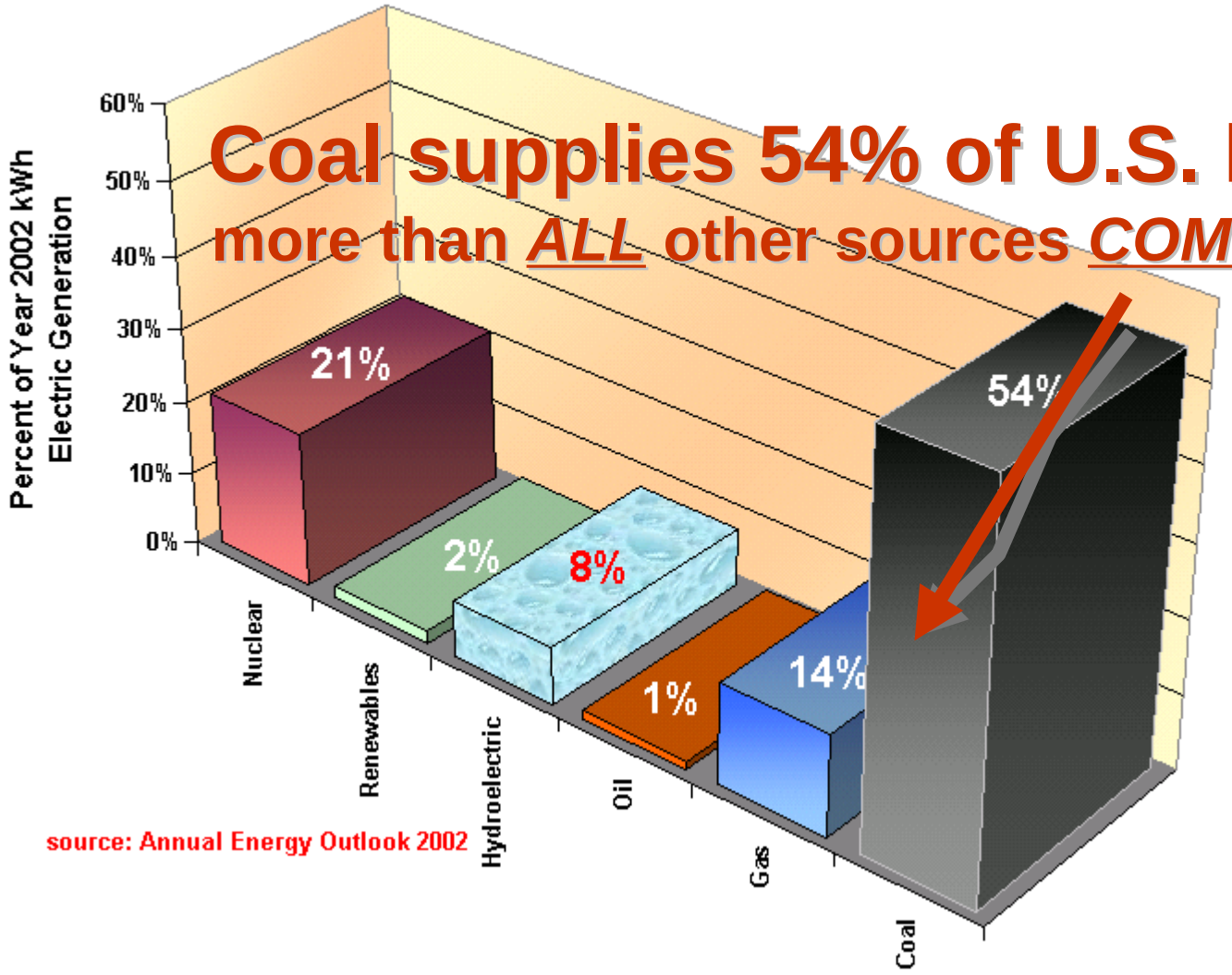
At present consumption rates, U.S. coal reserves are expected to last 275 years

Coal now accounts for more than half of the electricity generated in this country

Coal Is Electricity



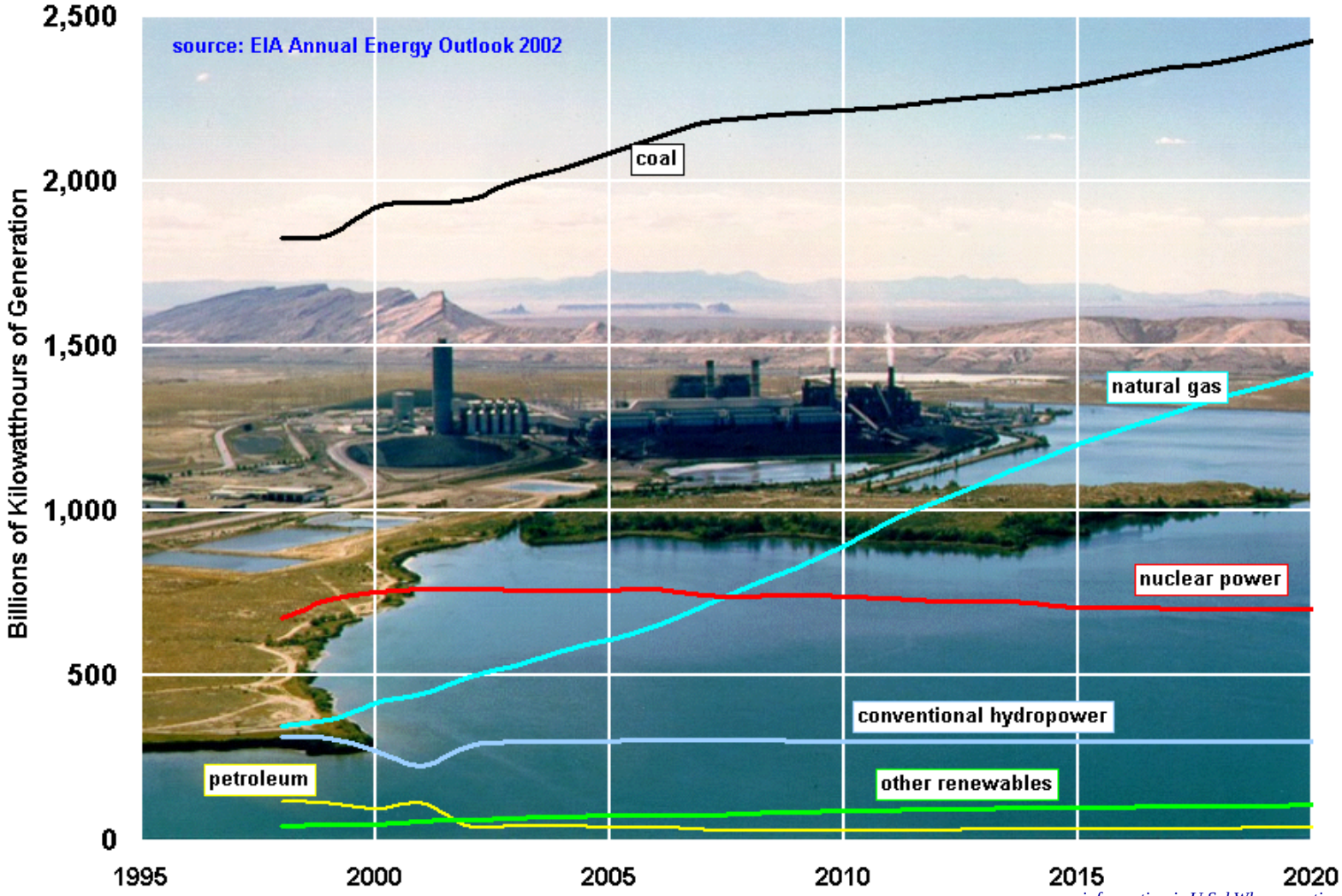
Coal Is Electricity



Coal *IS* Electricity

- Coal supplies more electricity than all other sources of energy combined
- Almost 90% of U.S. coal is used to generate electricity
- U.S. coal is abundant and secure
- Coal is an inexpensive source of electricity

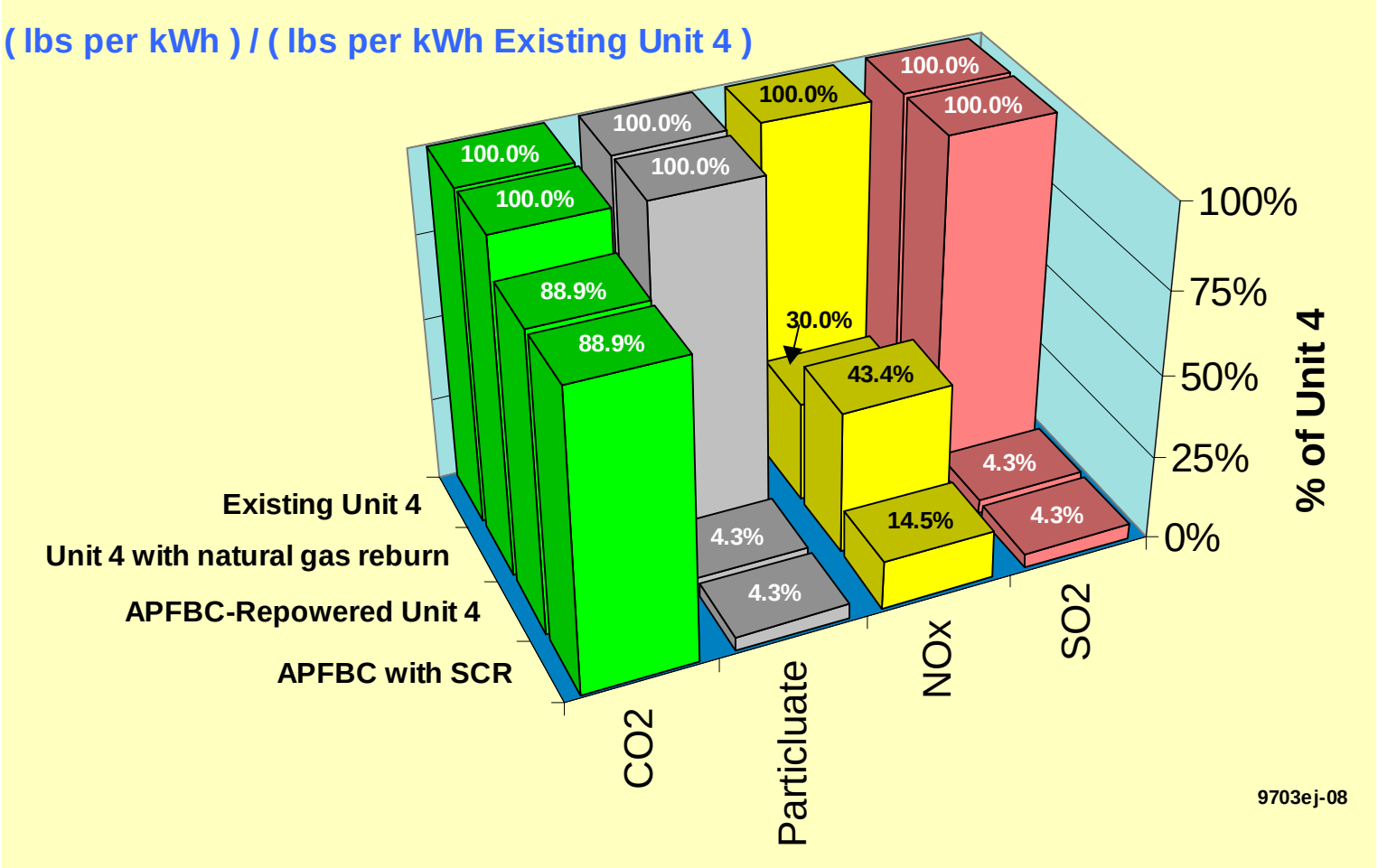
EIA Expectation Electric Generation kWh by Fuel Type



information is U.S. kWh generation by fuel type
source: AEO 2002, Table A.8
renewable and hydro, Table A.17

Clean Coal Technology is *VERY* Clean

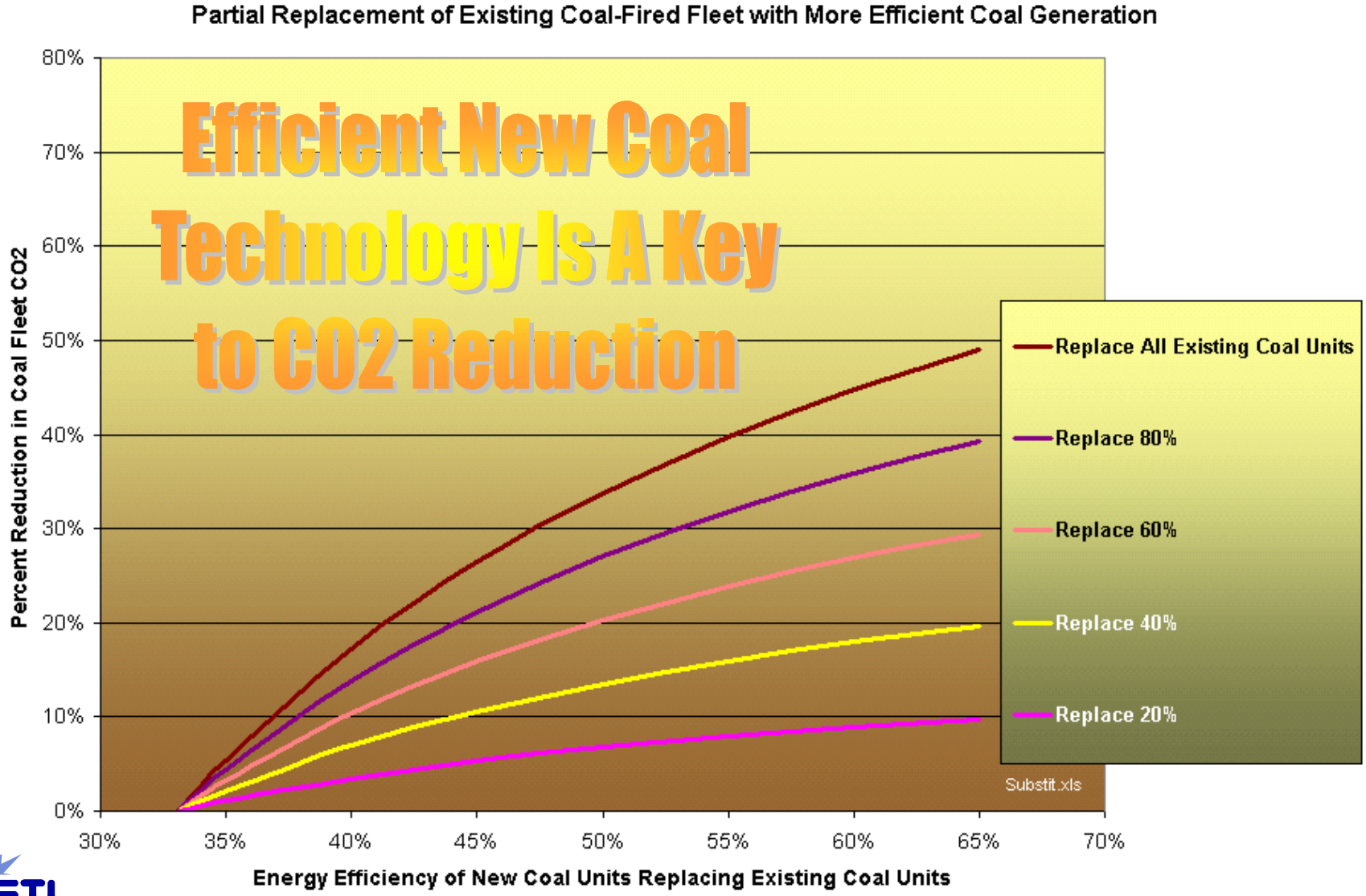
Here is how one CCT compares to an existing coal unit it might repower:



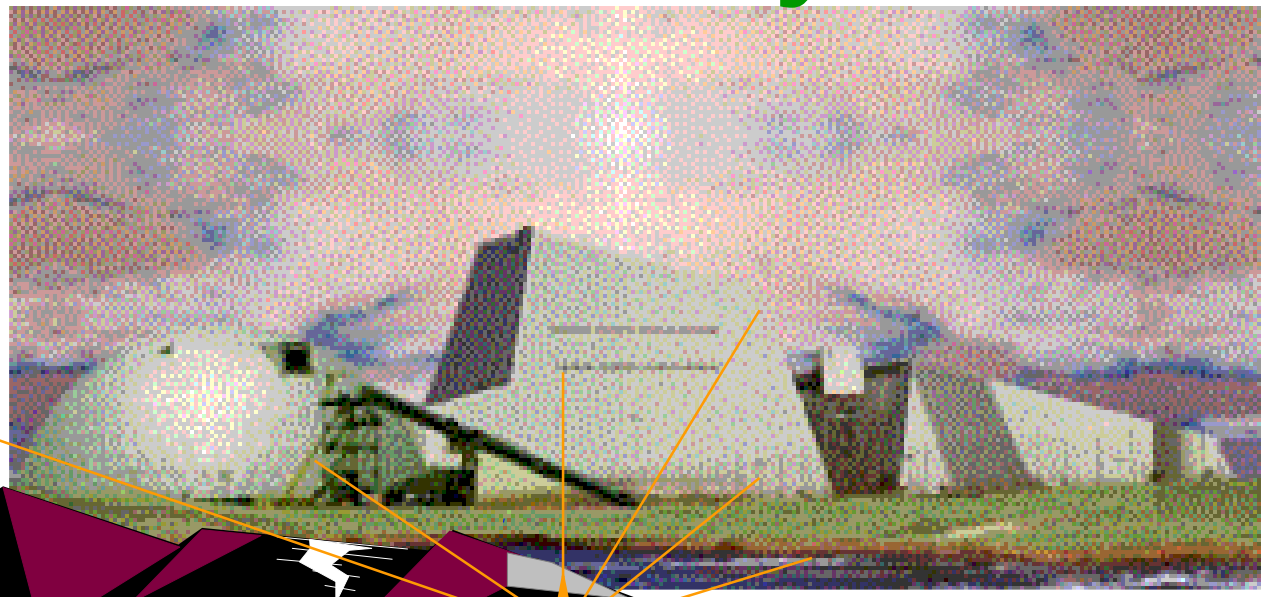
U.S. Coal Plants are High-Tech for Environmental Excellence

- **Coal is Cleaner than Ever-- Over the past 30 years:**
  - NOx emissions: Reduced by almost one-half
  - SO_2 emissions: Reduced by more than two thirds
  - Particulate emissions: One-tenth of what they were
- **The By-Products of Coal Combustion Can be Recycled**
  - Coal ash is concrete
  - Coal ash is food
- **Current Research Will Result in Even Cleaner Coal**
  - New Technologies will reduce emissions

Reduction in CO_2 Possible with Coal Units of Varying Efficiencies

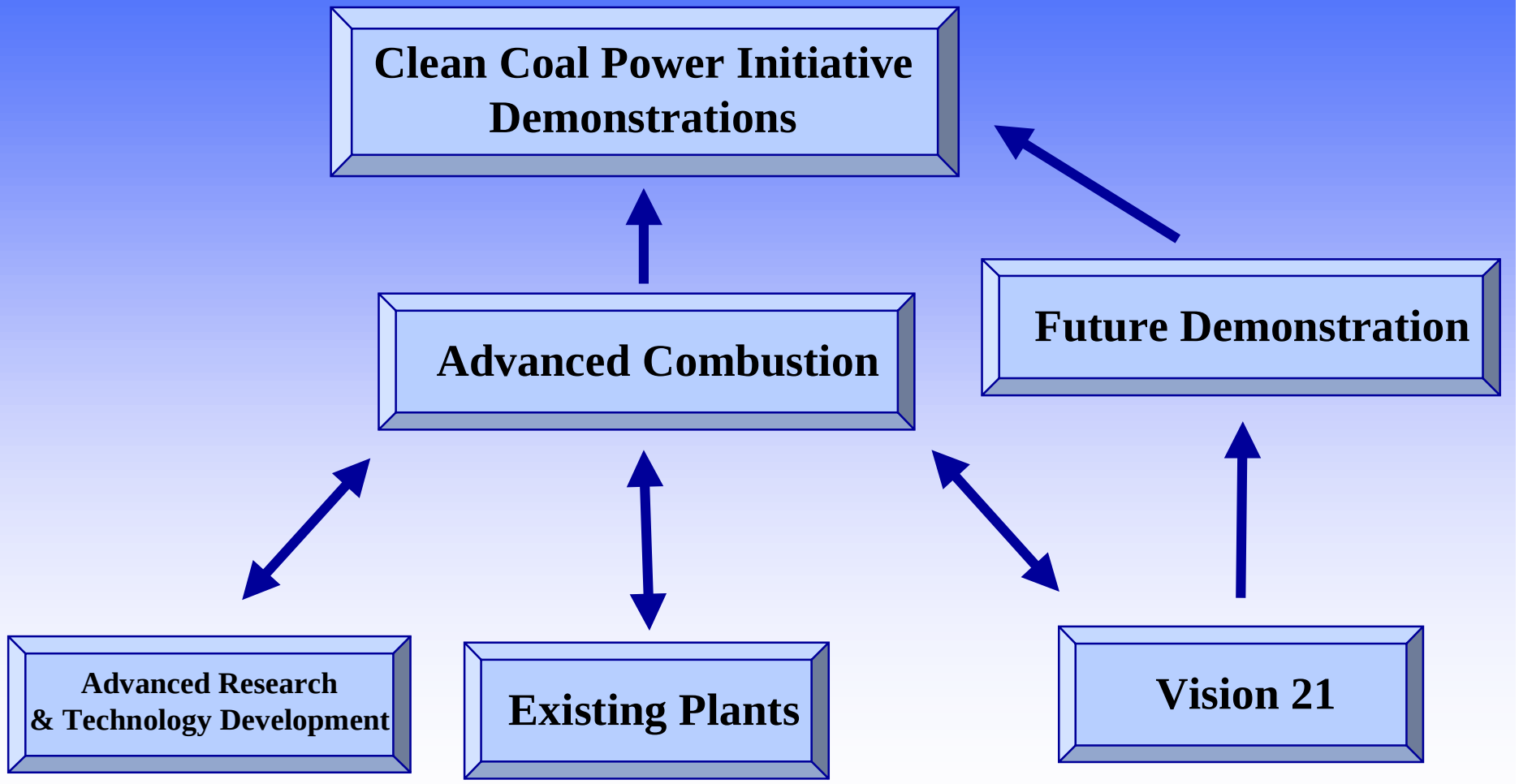


The Future of Electricity *IS* Coal!



DOE Vision 21 Energy Plex

Relationship of the Programs



Coal-Fired Generation Time Line

CCPI Project

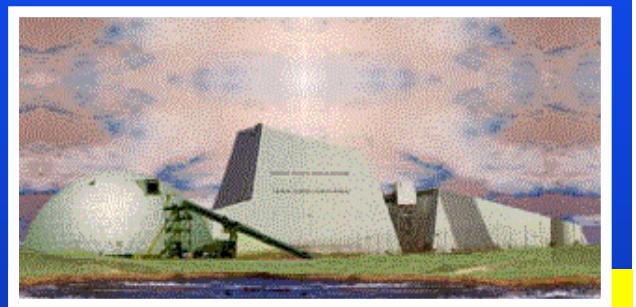
Sutton η = 32.0 %

L.V. Sutton electric generating station

Demo

η = 42.4 %

Combustion Technology Repowering



DOE Vision 21 Energy Plex

existing...

1950

fleet avg. η_{HHV} = 33.1 %

Now

ready in time...

repowering η_{HHV} = 43.5 %

greenfield η_{HHV} = 47.1 %

the future...

η_{HHV} = 60+ % →

but when ???

← ?

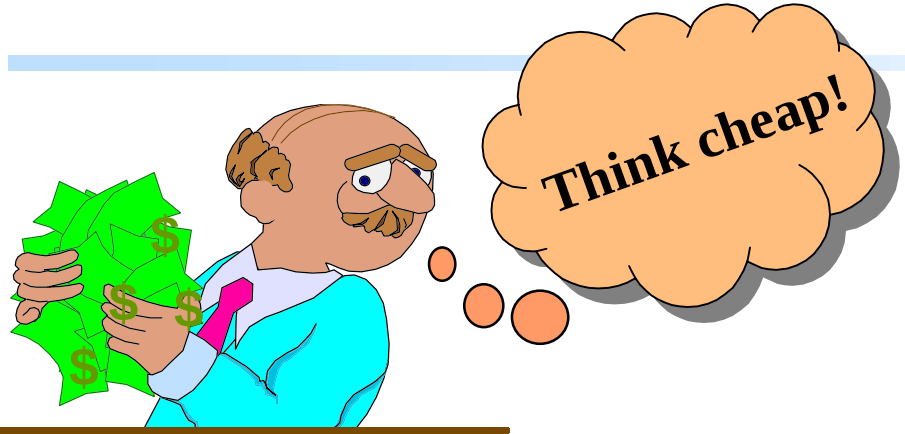
Mercury Reduction?

CO_2 Reduction Deadline?

Advanced Combustion Focus

Supercritical Steam Systems - 1400ºF+

- **Huntington Alloy V21 Materials Development**
  - Development of oxide dispersion-strengthened (ODS) alloys
- **Oak Ridge National Lab/ Huntington Metals**
  - allow oxide dispersion-strengthened (ODS) alloys to be used in the design, construction, and operation of heat exchangers in the very high-temperature environments of interest in Vision 21 power plant modules
- **Alstom Low Cost Combustor for Supercritical Systems**
  - Novel Combustor Concept Study
- **Alstrom Supercritical Steam System Optimization**
- **Award of New Supercritical Boiler Testing and Development Project in Negotiation**
- **Future, to Foster Application of Advanced Research Developments**



What Path to 1400°F?

- Better materials?
- Better/novel design with existing materials?
- Cheap replaceable parts?
- Cooled designs? *(only the steam path need be hot)*

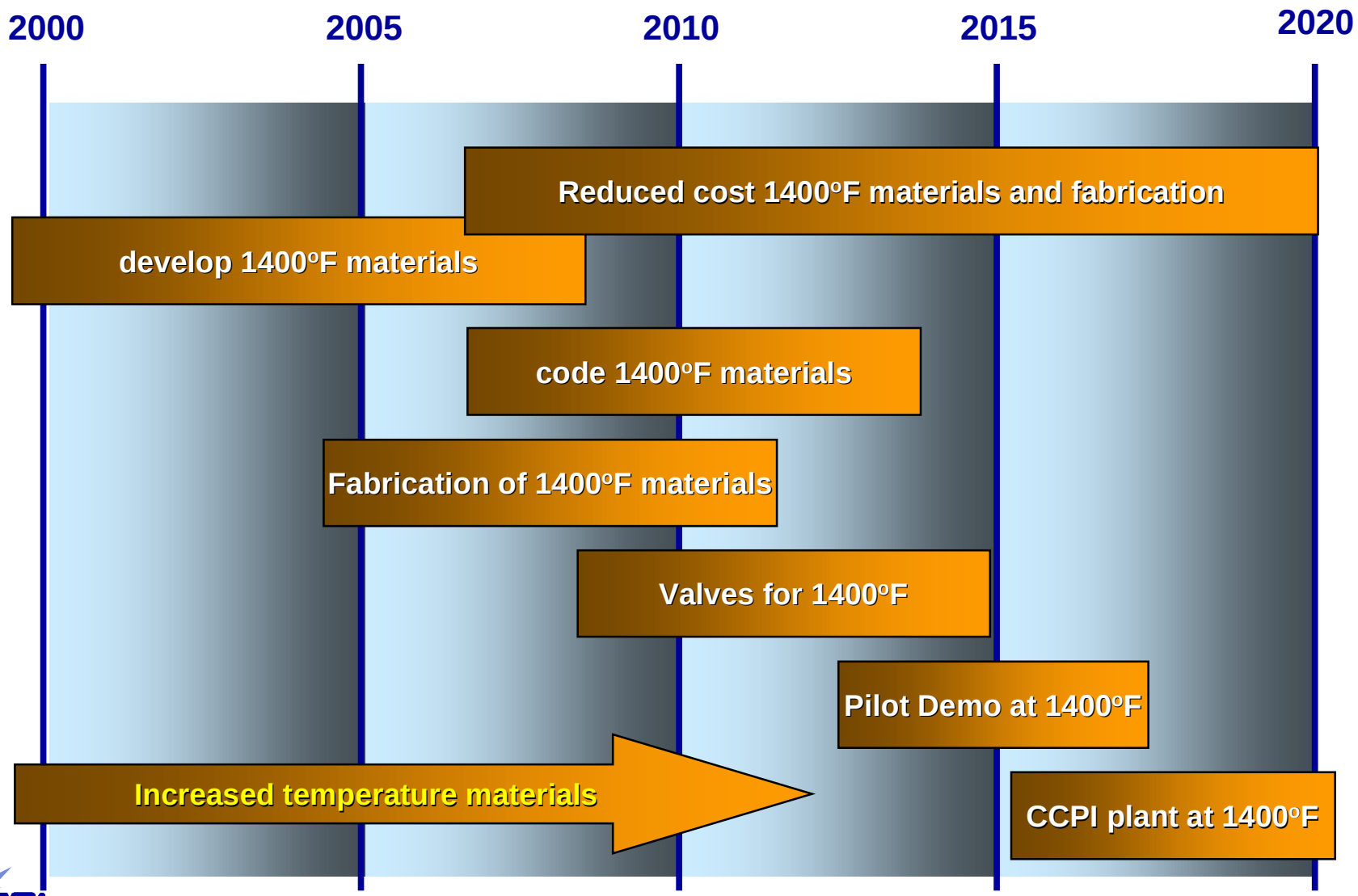
Ultrasupercritical Materials Program

- **The alloys that will be developed and evaluated in this program will have direct application in all advanced coal technologies that incorporate a Rankine steam cycle, including ultrasupercritical coal combustion systems, integrated gasification combined cycle plants, hybrid cycles incorporating partial gasification and fluid bed combustion, and gasification-fuel cell designs.**

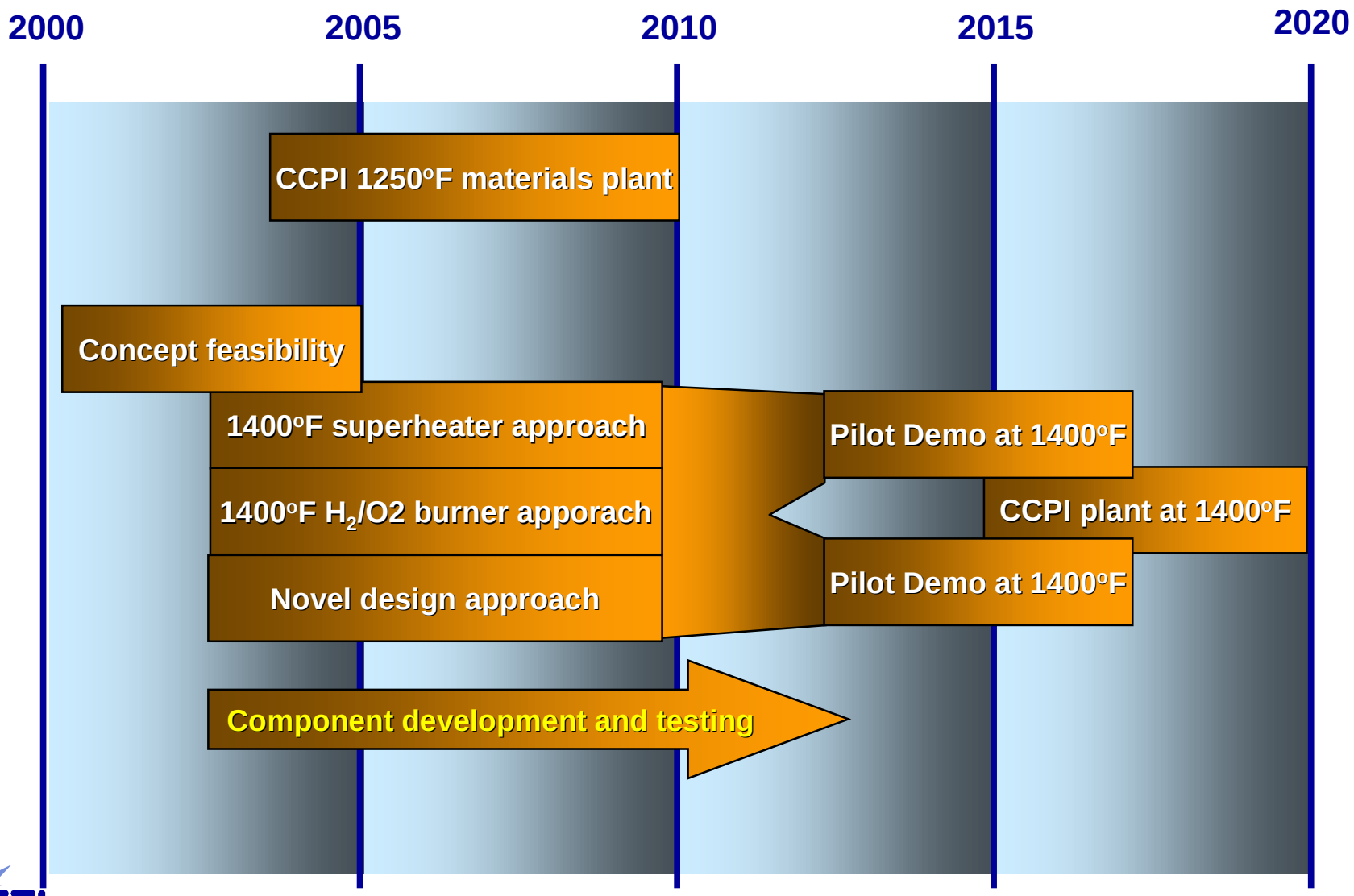
Ultrasupercritical Materials Program

- It is also possible to integrate ultrasupercritical steam conditions with oxygen blown combustion of pulverized coal. This approach further increases efficiency and produces a CO_2-rich off gas suitable for relatively low-cost CO_2 capture.

Combustion/Materials Program Interface



Path to 1400°F Ultra/Supercricital Steam Plant Design



Advanced Combustion Focus

Hot Gas Filtration Systems -1600^{o}F+

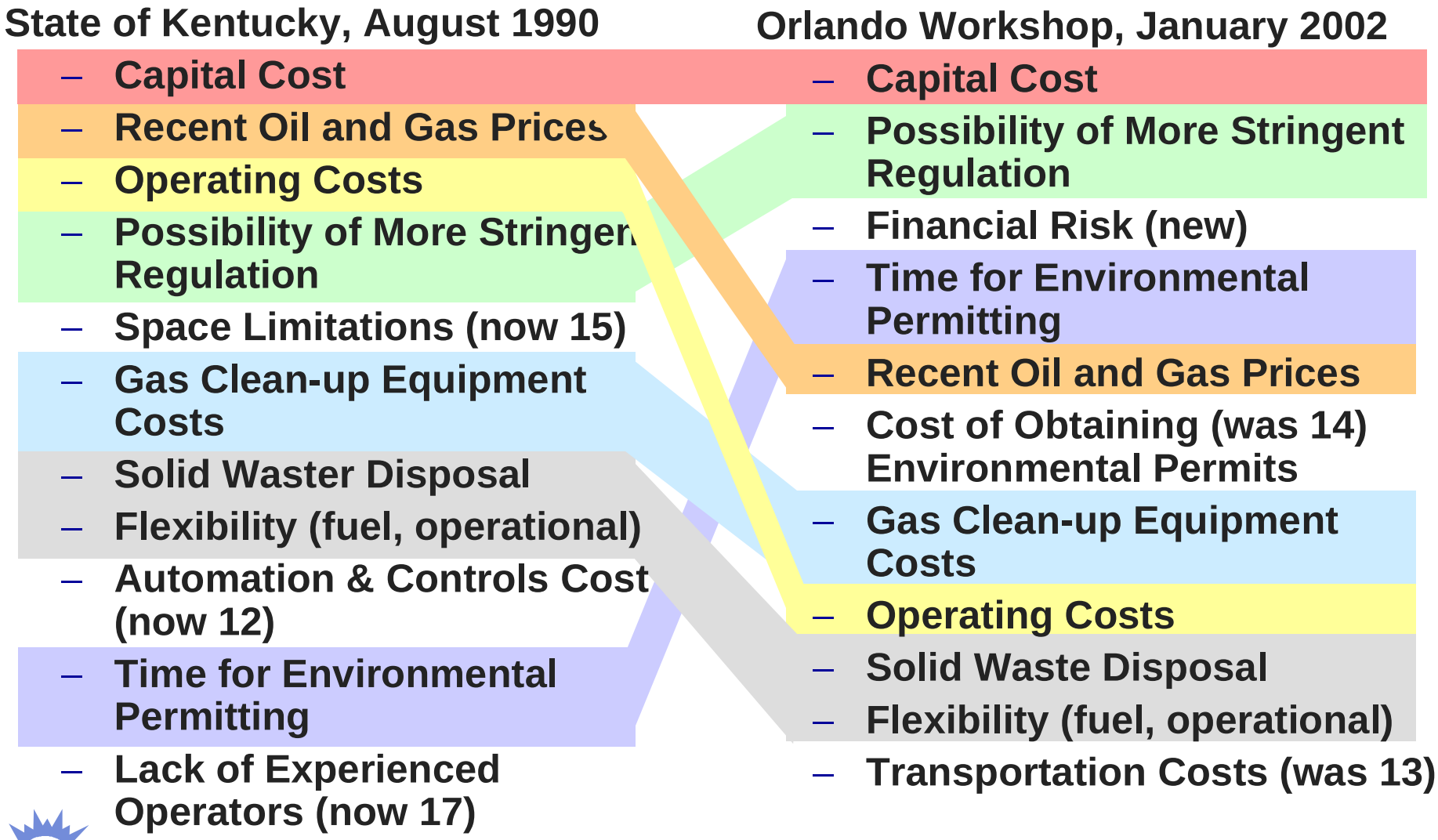
- **14 Active Projects Supporting Both Combustion and Gasifiication**
  - Low-Cost Iron Aluminide Filters
  - 13 Projects scheduled to expire by January 2003
- **Need to Refocus Hot Gas Filter Program**
  - Higher Temperatures - Push Toward 2100F
  - Multi-Contaminant Control and Gas Separation
- **Return to Basic and Continue Support Support of CCT and Future CCPI Projects**
  - Filter Safeguard Devices
  - Metal Filter for Hybrids
  - Increase Filter Durability and Lifetime Prediction
  - Optimization of advance Filter Configurations
  - Reduce Capital and operating Costs
  - Improve Nondestructive Testing
  - New Pilot Testing On Coal-Fired Units

Advanced Combustion Focus

Hybrid Systems

- **3 Active Projects Supporting Hybrid Combustion**
  - FW Vision 21 Circulating Partial Gasifier Fuel Flexible Proof Testing - Livingston, NJ
  - FW Scale-Up and Improved Fuel Feed Partial Gasifier Operation- Karahula, Finland
  - Repowering Studies at Various Power Generators
- **Future Need of Hybrid Systems to Support CCPI**
  - Expand Vendor Base
    - Proof testing of Other Hybrid Configurations
    - Solicit Novel Approaches
  - Expand Repowering Studies to Additional Power Generators and Sites
    - Continue Evolutionary Study Protocol
    - Incorporate Supercritical and Ultra-Supercritical Systems
    - Incorporate Co-Firing
    - Work on Incorporation of Advanced System Components into Existing Plants

Barriers to Coal Combustion Surveys



Market Requirements

Dramatic improvements in the economics of the pulverized coal (PC) power plant over the last decade have occurred in response to the deregulated power generation market to assure the financial success of power projects.

Future growth requires:

- **Superior Environmental Performance**
- **Plant Automation and Reliability Improvements**
- **Direct Equipment Costs Reductions**
- **Reduced Construction and Startup Schedule**
- **Performance Improvements Low Production Costs for Market Competition**
- **Operations Flexibility**
- **Fuels Flexibility**

Current Combustion Program

- **Vision 21 Goals of 60% Efficiency, Near Zero Emissions**
  - Are laudable and should be pursued to attempt a breakthrough for the future
  - Oxygen Based Combustion should be an integral part of the Combustion Program
- **Continue Development to Support CCPI Demonstrations**
  - Supercritical and Ultra Supercritical Steam Systems for PC and CFBC
  - Pressurized Systems
  - Hybrids
    - CHIPPS and GFBCC
  - Expand Repowering Studies to Educate Potential Users
  - Pressurized Feed and Ash Letdown

Future Advanced Combustion Systems Initiatives

- **RFP for innovative Vision 21 combustion concepts should be initiated**
- **Subprogram for Syngas/Hydrogen & Catalytic Combustors**
- **More Innovative Pressurized Feeder and Letdown Systems**
- **Oxygen Combustion**
  - Model 100% oxygen fired furnace to define R&D needs (heat transfer, emissions, economics)
  - Investigate Ash/Slagging for Oxygen and Enhanced Oxygen Application
- **Hot Gas Filtration and Clean-Up**
  - Develop multi-pollutant collection
  - Find new Sorbents
  - Increase operating temperatures to 2000ºF and higher
- **Advanced Coal-Fired Peakers**
  - Investigate various system options and characterize economic/market

Crosscutting – AR&TD, Existing Plant Improvements, and Combustion

- Enhanced Oxygen Retrofits for PC and Cyclones
- Computational Modeling for All Combustion Systems
- Impacts and Operational Parameter of Flue Gas (CO_2) Recycle on All System
- Develop Steam Cycle Above 1500^{o}F and Coded Materials
- Materials Development Issues for Erosion, Corrosion In Advanced Temperature and Gas Environments
- Improved Instrumentation and Control in Conventional and Advanced Environments
- Condenser, Circulating,Cooling Water & Waste Heat Recovery Improvements

What Can We Do To Promote Future Combustion Technologies

COMBUSTION TECHNOLOGIES UNIVERSITY ALLIANCE (CTUA)

Collaboration and Communication
Between
University, Industry, and Government Researchers

What is the Combustion Technologies University Alliance

- The model for the University Alliance is the University Consortium
- The Alliance is based out of NETL's Office of in-house research (OST)rather than a major University
- Membership in the Alliance is free and open to any University and its partners that are willing and able to collaborate in quality applied combustion R&D projects

Application for Alliance Membership

- **In the Alliance, "the purpose is to collaborate and communicate, not just belong"**
  - Sign-up to be a reviewer of the overall combustion program, including future Clean Coal Power Initiative solicitations

OR

  - Submit proposals to NETL which can be awarded for Applied R&D projects that support the Combustion Technologies Program and its Vision 21 goals.

Examples of CTUA Projects

- **IOWA STATE --- Advance Combustor and Small Turbine Testing --- *Aid small Iowa business prove novel concepts***

- **PENN STATE --- Bed Ash Cooler --- *Aid industry in improving bed ash coolers and their application***

- **WESTERN KENTUCKY --- CFB Facility Planning --- A *collaboration with Industry and Government researchers***

POTENTIAL PROCUREMENT VEHICLES
for
Combustion Technologies University Alliance

- **Small Purchases** **$ 25,000**
- **Fixed Obligations Assistance** **$ 100,000**
- **Board Base Assistance** **$?,100,000**
- **CRADAs** **$ 0**
- **Task Order Contracts** **$???,???**

Technology Performance Goals

Performance	Conventional System	LEBS (2003)	Advanced Systems (2008)	Advanced Systems (2012)
Emissions: ($lb/10^6 Btu$)				
SO_2	**0.6**	**0.1**	**0.06**	**0.06**
NOx	**0.6**	**0.1**	**0.06**	**0.06**
Particulate Matter	**0.03**	**0.01**	**0.003**	**0.003**
Thermal Efficiency: (Net, based on fuel HHV)	**35%**	**42–45%**	**47–50%**	**55%**
Cost of Electricity: (Relative)	**100%**	**90%**	**85%**	**80%**

What Would the U.S. Be Like Without the Combustion of Coal?